Optimal Media Mix - Evaluating the Impact of Advertisement Expenditures of Different Media

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OPTIMAL MEDIA MIX - EVALUATING THE IMPACT OF ADVERTISEMENT EXPENDITURES OF DIFFERENT MEDIA

Saumitra N Bhaduri, S Raja Sethu Durai and David J Fogarty

Abstract

The paper evaluates the impact of advertising expenditures of different media in getting the new loan applications. Focusing on the consumer finance business of a large financial company of Norway, this paper analyses the efficiency of advertising expenditures on three media – TV, Print and the Internet. Using a Data Envelopment Analysis (DEA) method, it assesses the overall efficiency of the media and the effective combinations in attracting new loan applications. The efficiency score developed in this paper clearly recognizes the best practices weeks, with that we can identify the best combination of media, which serves the purpose best in terms of acquiring new loan applications. Finally, a media mix builder is developed to guide the business for the future strategies.

Keywords: Optimal media mix; Advertising efficiency; Data envelopment analysis.

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1. INTRODUCTION

John Wanamaker, founder of the first department store and considered to be the father of modern advertising once stated "Half the money I spend on advertising is wasted: the trouble is, I don't know which half." The theoretical expectations of advertising practice are not fully satisfied in reality. High level of advertising inefficiency has been recognized and documented in the marketing literature by many studies. Bass (1979) observed that much of the advertising spending is wasted and the level of waste for some companies could reach as high as 407% of their net income. Since large sum of money is spent on advertising this documented inefficiencies are a cause of worry for all the practitioners and the business.

Since the 1960's there have been a few efforts by the research community to empirically evaluate the efficiency of advertising and to suggest ways to increase that efficiency. In 1978, Charnes, Cooper, and Rhodes developed Data Envelopment Analysis (DEA), a non-parametric methodology for benchmarking efficiency. Luo and Donthu (2001) are the first to use the DEA in analyzing the efficiency of advertising expenditures. The advertising industry will continue to be revolutionized by quantitative analyses. In the past many firms assumed that the world of advertising and branding was an art and didn't apply much scientific rigor in measuring the effectiveness of this marketing activity. The reason for this is probably historical due to the creative aspects of formulating messages and the very difficult task of measuring and quantifying human behavior. Today, however, the use of quantitative methods to analyze the efficiency of advertising expenditures is becoming increasingly important to firms as global competition is forcing them to prioritize their advertising budgets on a worldwide basis.

Moreover, the web channel is increasingly taking a higher percentage of advertising spend as demonstrated in Google's recent success in significantly growing its revenues and profits. The Web channel also provides an easier way to track the effectiveness of each advertising message (Davenport and Harris, 2007).

Using weekly data on the advertising expenditure of consumer finance business of Norway, this paper identifies the best practice weeks using DEA method. The paper is organized as follows: Section 2 gives a brief literature review on efficiency measurements with its two procedures and the DEA methodology. Section 3 narrates the description of the data used. Section 4 provides the results. Section 5 explains the construct of media mix builder developed for future strategic guidance and finally, the conclusions are provided in section 6.

2. EFFICIENCY MEASUREMENT

Modern efficiency measurement begins with Farrell (1957) who drew upon the work of Debreu (1951) and Koopmans (1951) to define a simple measure of efficiency, which could account for multiple inputs. He theorized that a firm efficiency consists of two components: *technical efficiency*, which reflects the ability of a firm to obtain maximum output with a given set of inputs and *allocative efficiency*, which reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices. The product of these two measures provides the total *economic efficiency* of a firm.

Following Farrell (1957), two different measures are gained prominence in the efficiency measurement literature, namely the *input-oriented* measure and the *output-oriented* measure.

2.1 Input-Oriented Measures

A simple example is illustrated in Figure 1. Consider a firm that uses two inputs (x_1 and x_2) to produce one output (y). Under the assumption of constant returns to scale, SS^I curve represents the efficient isoquant. If a firm uses quantities of inputs defined by the point P, to produce a unit output, the distance QP defines the technical inefficiency of the firm, since Q is technically efficient as it lies in the efficient isoquant. So *technical efficiency* $TE_I = OQ/OP$. The TE_I takes the value between zero and one and gives the degree of technical efficiency. A value of one indicates the firm is fully technically efficient.

If the input price ratio, represented by the line AA^I is known then the *allocative efficiency* of the firm operating at the point P is $AE_I = OR/OQ$. Here Q is technically efficient and allocative inefficient point. The distance RQ represents the production costs which should be reduced to push it to the efficient point Q^I.

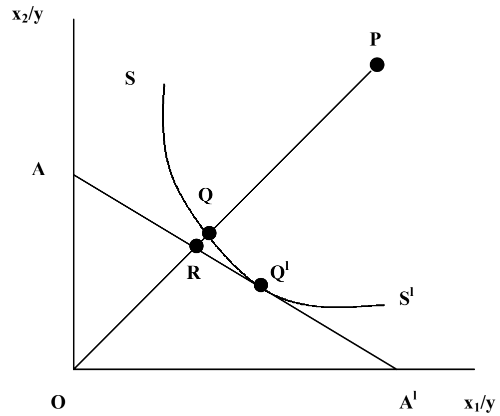


Figure 1: *Input Oriented Measure of Technical and Allocative Efficiency*

2.2 Output-Oriented Measures

The input-oriented measure addresses the question: " By how much can the input quantities be proportionally reduced without changing the output produced?" Instead we can also ask, " By how much can the output quantities be proportionally expanded without changing the inputs used?" This provides us the output-oriented measure. An example is illustrated in Figure 2.

Consider a firm that produces two outputs (y_1 and y_2) with one input (x). In Figure 2, the line ZZ^I represents the production possibility curve. A firm operating at point A is an inefficient firm. Here the distance AB is technical inefficiency of the firm, since the point B lies in the production possibility curve. The *technical efficiency* TE_o = OA/OB. If we have the price information we can construct the isorevenue curve DD^I and define the *allocative efficiency* as follows:

$$AE_o = OB/OC.$$

To bridge the distance BC, the inputs has to be increased to attain allocation efficiency.

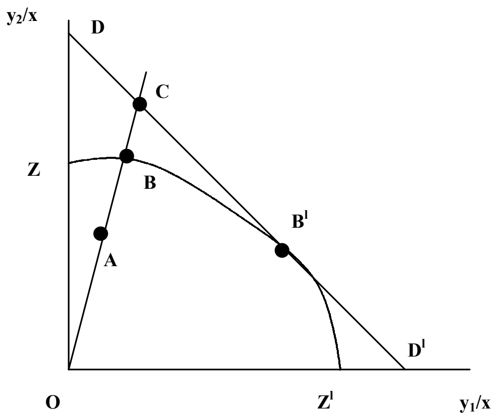


Figure 2: *Output Oriented Measure of Technical and Allocative Efficiency*

2.3 Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a non-parametric mathematical programming approach to evaluate the relative efficiency of comparable firms. Charnes, Cooper, and Rhodes (1978) introduced a DEA model, which formed the basis for all subsequent developments in DEA and called as CCR model. The CCR model introduced the generic term 'Decision Making Units' (DMUs) to describe the collection of units which have common inputs and outputs and which are being assessed for efficiency. The CCR had an input orientation and assumed constant returns to scale (CRS). Subsequently the CRS assumption is only suitable if all the DMU's in question operates at an optimal scale. But imperfect competition and other operating constraints force the DMUs to a variable returns to scale (VRS), which was first proposed, by Banker, Charnes and Cooper (1984). Both output orientated and input orientated models are very similar dual problems. The generic input orientated model is as follows:

$$\min \theta - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta\, x_{ij_0} \qquad i = 1,2,\ldots., m$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{rj_0} \qquad r = 1,2,\ldots., s$$

$$\sum_{j=1}^{n} \lambda_j = 1 \quad \lambda_j \geq 0 \qquad j = 1,2,\ldots., n \qquad (1)$$

where DMU_{jo} represents one of the n DMUs under evaluation, and x_{ijo} and y_{rjo} are the i^{th} input and r^{th} output for DMU_o respectively and s_i^- and s_r^+ represent the i^{th} input and r^{th} output slacks. ε is non-Archimedean, which allows minimization over θ. By solving (1) we get optimal solutions θ^* and λ^*. If the efficiency score θ^* is equal to 1 then the DMU is operating at the efficient frontier and the input levels are optimal. If the score is less than 1 then the current input level are suboptimal and it should reduce the current inputs to the level of its reference sets, represented by λ^*. The output-orientated model is as follows:

$$\max_{\phi,\lambda} \phi,$$

subject to $-\phi\, y_i + Y\lambda \geq 0,$

$$x_i - X\lambda \geq 0,$$

$$N1'\lambda = 1, \quad \lambda \geq 0$$

where $1 \leq \phi < \infty$, and $\phi - 1$ is the proportional increase in outputs that could be achieved by the i-th DMU, with input quantities held constant. N1 is an Nx1 vector of ones. This convexity constraint $N1'\lambda = 1$ represents the scale; if it is included then the model assumes variable returns to scale (VRS).

2.4 Estimation

There is no standard routine available in SAS to estimate this DEA model. There are plenty of freeware available in the Internet to do this DEA estimation. We used a freeware called DEAP 1.1 to estimate the weekly efficiency score.

3. DATA

Data from a large consumer finance business in Norway have been used in this study. We considered the data on media expenditure for the closed end loans. Weekly total cost on three different media namely, TV, Internet and Print are considered as inputs and approved new loans and calls received are considered as output. The data is available from first week of 2004 to twenty sixth week of 2006. Totally 105 weeks are available for the analysis. The average cost per week in Norwegian Krone (local currency) for each media is given in Table 1. It clearly shows that the business spend more amount on TV, followed by Print and then the new media Internet. Before going into the DEA analysis to estimate the efficiency score for each week, two preprocessing of the data is required to make each week comparable. First, the seasonal effect in the output data has to be normalized with deseasonalization. Second the spillover effects of the media over the weeks are to be standardized.

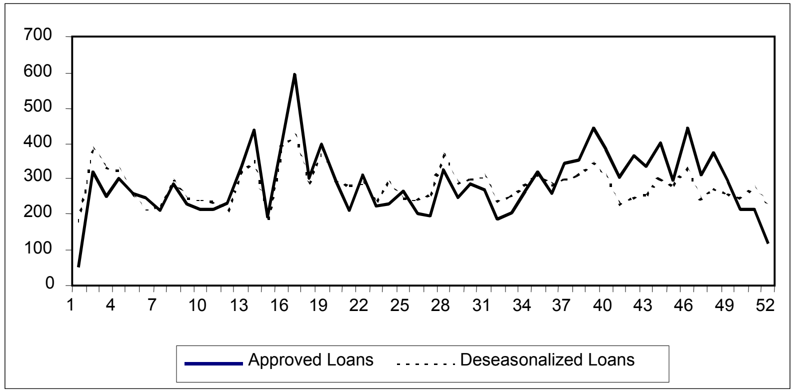
Table 1: Average Cost Per Week

Media	Average Cost			
	2004	2005	2006	Total
TV	180787	321961	461945	296201
Print	137433	100013	185036	124016
Internet	16728	33182	49994	30768

3.1 Deseasonalization

A simple seasonal index is used to deseasonalize the data. The construction of the seasonal index for each week is as follows. First, calculate the average approved new loan applications for the entire time period. Second, take the ratio of the actual approved new loan application in a particular week and the average approved new loan applications. Third the seasonal index for the first week of January is calculated as the average of the estimated ratios in the 1st week of January in 2004, 2005 and 2006. Further dividing the actual approved new loan applications in a particular week with this seasonal index will give the deseasonalized value for that week. Figure 3 depicts the actual and deseasonalized data for the year 2004.

Figure 3: Actual and Deseasonalized Output Data for 2004



3.2 Adjusting Spillover Effects

An advertisement through a media or a combination of media in a particular week might have spillover effects in the following weeks in getting the new applications. In simple words it means that an application in a particular week might not only be influenced by the advertisements in that particular week, but it might be a reflection of the advertisements in the previous weeks as well. This spillover effects has to be adjusted to get an unbiased estimate of the efficiency score. To identify the spillover effect a distributed lag regression model is used. The result of that model is given in Table 2 for the approved new loans and Table 3 for the calls received.

Table 2: Spillover Effects on Approved New Loans

	Coefficients	*Standard Error*	*T Stat*	*P-value*
Intercept	106.856	6.57344	16.256	0.000
TV	0.00006	0.00002	3.315	0.001
Internet	0.00025	0.00008	3.092	0.003
Print	0.00009	0.00003	3.226	0.002
TV(-1)	0.00006	0.00002	3.386	0.001
Print(-3)	0.00009	0.00003	3.522	0.001

Regression Statistics	
R Square	0.451
F Statistics	15.818
P Value	0.000
Observations	105

Table 3: Spillover Effects on Calls Received

	Coefficients	*Standard Error*	*T Stat*	*P-value*
Intercept	1213.2	66.364	18.282	0.000
Print	0.0013	0.0003	3.791	0.000
Print (-2)	0.0010	0.0003	2.871	0.005

Regression Statistics	
R Square	0.232
F Statistics	15.096
P Value	0.000
Observations	105

3.3 Model

DEA output orientated model with variable returns to scale is used in this weekly analysis of media expenditures. Efficient weeks or best practices are identified as the weeks which have generated the maximum approved loans, given all the possible combinations of media expenditure that has been used in the sample. The model is as follows:

$$\max \delta$$

$$\text{s.t } \sum \lambda_j (TV)_j \geq (TV)_{jo}$$

$$\text{s.t } \sum \lambda_j (\Pr\text{int})_j \geq (\Pr\text{int})_{jo}$$

$$\text{s.t } \sum \lambda_j (Internet)_j \geq (Internet)_{jo}$$

$$\delta (Output)_{jo} \geq \sum \lambda_j (Output)_j$$

$$\sum \lambda_j = 1$$

$\lambda_j \geq 0$, *j = weeks 1, 2, …, N*

where δ = inefficiency parameter and λ = weights. In this model the objective of the linear program is to maximize output production, with the given set of inputs.

4. RESULTS

Total cost per week for three different media namely TV, Print and Internet are considered as input and the seasonally adjusted data on approved new loans and calls received are used as output to estimate the efficiency score for each week using DEA methodology. Assuming variable returns to scale (VRS) and output orientation, the average efficiency score for all the 105 weeks is 0.888. Totally 27 weeks are identified as best practices weeks with efficiency score of 1. In those 27 weeks, 14 weeks are identified in 2004, 6 weeks in 2005 and 7 weeks in 2006. Table 4 gives the number of times a particular combination of media appeared in the best practices week. Using all three media and the combination of Internet & Print appears 6 times each out of 27 best practices weeks followed by Only Internet appearing 5 times. The other combinations appear 3 times each except Only TV that appears only one time. Using these best practices weeks and the estimated peers for each inefficient week we validate the model in terms of incremental benefits in approved new loans and construct a media mix builder to effectively implement the model for future strategies. For validation we regrouped the 105 weeks spanning across 3 years into 50 weeks starting from 1st week of January to 3rd week of December.

Table 4: Combination in Best Practices Weeks

Combination	Number of Times it appears
Only TV	1
Only Print	3
Only Internet	5
Internet & Print	6
TV & Print	3
TV & Internet	3
All Three	6

4.1 Validation

The model validation has been done by calculating the incremental benefits in new approved loans. For each inefficient week the DEA model has identified its peers. There is a possibility that the DEA can identify more than one peer. In that case the peer having highest approved new loans has been considered as peer for that particular week. The incremental benefit is calculated as the difference between the actual seasonally adjusted approved new loans for a particular week and the seasonally adjusted approved new loans of its peer. For an efficient week, the peer is the week itself, so the incremental benefit is zero for efficient weeks. The total incremental benefit is calculated as 6179 seasonally adjusted approved new loans, which is 38 % of the actual adjusted approved new loans.

5. MEDIA MIX BUILDER

The paper finally develops a media mix builder to create the annual plan for the business based on the proposed model.

A snap shot of the developed Media Mix Builder is given in Figure 4. Given the budget for a week the media mix builder will provide the details of the minimum budget for the week and the best combination of media with the expenditure details.

Insert Your Budget for the

Target Output includes the Spillover

Media-Mix Builder

Month	Week	Total Budget	Minimum Budget	Comment on Budget	BP (Replicate)	Combination	TV	Internet	Print	Target Output
Jan	1	250000	171930	Minimum Budget Statisfied	1/2005	Internet & Print	0	6407	243593	456
	2	500000	19063	Minimum Budget Statisfied	3/2006	Only Internet	0	500000	0	4763
	3	32000	13449	Minimum Budget Statisfied	3/2004	Internet & Print	0	22603	9397	462
	4	50000	468198	Lesser than the Minimum Budget	5/2006	TV & Internet	45279	4721	0	55
	5						0	0	0	0
Feb	1						0	0	0	0
	2						0	0	0	0
	3						0	0	0	0
	4						0	0	0	0
	5									

Figure 4: Snap Shot of the Media Mix Builder

6. CONCLUSIONS

The paper develops an optimal media mix model to evaluate the effect of different media expenditure in getting the approved new loans to the business. Weekly data on three inputs namely the total cost per week for TV, Print and Internet and two outputs namely approved new loans and calls received per week are used in a DEA framework to estimate the efficiency score along with the peers for each week. The results identified 27 weeks out of 105 weeks as efficient weeks. The incremental benefits are estimated at 38 % , which means that with the given inputs the business can either improve the output or reduce the cost by 38 % with the given set of inputs and outputs respectively. Finally a media mix builder has been developed with the score and the peers' information for future strategies.

Sir Martin Sorell, CEO of WPP Group one of the world's largest advertising agencies calls econometrics the holy grail of advertising. Moreover, several top advertising agencies have now created teams of econometricians to do this type of analysis for clients. It is expected that firms will increasingly view analytics about advertising as a necessary adjunct to embarking upon any campaign (Davenport and Harris, 2007). Therefore this research and further research in this area is necessary to insure that advertising resources are well spent.

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